CLAIMS

1. A laser processing apparatus comprising:

a laser source;

a spatial phase modulator configured to modulate a phase of a laser beam emitted from the laser source;

a synthetic data generator configured to generate synthetic data by combining hologram image data representing a pattern image to be processed with position displacement hologram data for shifting the pattern image to a prescribed position, said synthetic data being input to the spatial phase modulator for the phase modulation of the laser beams; and

a focusing optical unit configured to guide the phase-modulated laser beam onto a surface to be processed to reproduce the pattern image on the processed surface.

2. The laser processing apparatus of claim 1, wherein the position displacement hologram data include either a horizontal hologram data set representing displacement in a direction parallel to the processed surface, a vertical hologram data set representing displacement in a direction perpendicular to the processed surface, or a combination of the horizontal and vertical hologram data sets.

3. The laser processing apparatus of claim 2, wherein the

horizontal hologram data set has substantially a sawtooth phase distribution profile.

4. The laser processing apparatus of claim 2, wherein the vertical hologram data set has a phase distribution profile similar to a Fresnel zone plate.

5. The laser processing apparatus of claim 4, wherein a distance from the spatial phase modulator to the focusing optical unit is equal to a focal length of the focusing optical unit.

6. The laser processing apparatus of claim 1, further comprising:

a wavefront measuring unit configured to measure a wavefront of the laser beam input to the spatial phase generator;

wherein the synthetic data generator generates correction data for correcting distortion of the wavefront of the laser beam detected by the wavefront measuring unit, and the correction data are supplied to the spatial phase modulator.

7. The laser processing apparatus of claim 1, further comprising at least one of:

an irradiation time adjusting unit configured to regulate irradiation time of the laser beam; and

a beam intensity adjusting unit configured to regulate an

intensity of the laser beam.

8. The laser processing apparatus of claim 2, further comprising:

a horizontal-direction position detector configured to detect a horizontal position in a plane parallel to the processed surface;

wherein the synthetic data generator generates the horizontal hologram data set based on the detection result.

9. The laser processing apparatus of claim 8, wherein the horizontal-direction position detector detects a reference pattern formed on the processed surface.

10. The laser processing apparatus of claim 1, further comprising:

a first driving unit configured to move a light spot of the laser beam relative to the processed surface in a direction parallel to the processed surface.

11. The laser processing apparatus of claim 2, further comprising:

a vertical-direction position detector configured to detect a positional relation between the focusing optical unit and the processed surface in a direction perpendicular to the processed surface;

wherein the synthetic data generator generates the vertical

hologram data set based on the detection result.

12. The laser processing apparatus of claim 1, further comprising:

a second driving unit configured to move a position of the processed surface relative to the focusing optical unit in a direction perpendicular to the processed surface.

13. The laser processing apparatus of claim 1, wherein the laser source is an ultra-short pulse laser source with a pulse width at or below several picoseconds.

14. A laser processing method comprising the steps of:

calculating hologram image data representing a pattern image to be processed on a object;

generating position displacement data for shifting the pattern image to a prescribed position with respect to a processed surface of the object;

combining the hologram image data with the position displacement data to produce synthetic hologram data;

modulating a phase of a laser beam using the synthetic hologram data; and

guiding the phase-modulated laser beam onto the processed surface using an optical system.

15. The laser processing method of claim 14, further comprising the step of:

setting a distance between a phase modulating position and the optical system equal to a focal length of the optical system.

16. A computer program product configured to cause a computer to execute the steps of:

calculating hologram image representing a pattern image to be processed on an object;

generating position displacement data for shifting the pattern image to a prescribed position with respect to a processed surface of the object;

combining the hologram image data with the position displacement data to produce synthetic hologram data; and

inputting the synthetic hologram data to a phase modulator to control phase modulation performed on a laser beam.

17. The computer program product of claim 16, further causing the computer to execute the step of:

generating either a horizontal hologram data set representing displacement in a direction parallel to the processed surface, a vertical hologram data set representing displacement in a direction perpendicular to the processed surface, or a combination of the horizontal and vertical hologram data set as the position

displacement data.

18. The computer program product of claim 17, wherein the computer executes the step of generating the horizontal hologram data set having substantially a sawtooth phase distribution profile.

19. The computer program product of claim 17, wherein the computer executes the step of generating the vertical hologram data set having a phase distribution similar to a Fresnel zone plate.